DRAFT DRAFT DRAFT

USGS
science for a changing world



Prepared for U.S. Environmental Protection Agency

# Denver Microbeam Laboratory Administrative Report No. 220805

by Gregory Meeker

22 August 2005

Department of the Interior
U.S. Geological Survey

## Introduction

Seven vermiculite samples were submitted by Peggy Churchill, EPA, for analyses by electron probe microanalysis (EPMA). The samples were collected from locations at a high school in Troy, Montana. The purpose of the analyses was to determine the likely source or sources of biotite, hydrobiotite, and vermiculite (collectively called vermiculite in this report) collected at the high school. All analyses were performed at the U.S. Geological Survey, Denver Microbeam Laboratory.

## Sample Identification

| Sample # | Description |
|---|---|
| CS20342 | Processed vermiculite |
| CS20344 | Processed vermiculite |
| CS20346 | Processed vermiculite |
| CS20348 | Processed vermiculite |
| CS20350 | Processed vermiculite |
| CS20352 | Processed vermiculite |
| CS20354 | Processed vermiculite |

## USGS Sub-Sample Numbers and Data Identification

EPMA Job Identification: Troy-Verm
EPMA Sub-sample Numbers:

- CS20342: Polished grain mount of sample CS20342
- CS20344: Polished grain mount of sample CS20344
- CS20346: Polished grain mount of sample CS20346
- CS20348: Polished grain mount of sample CS20348
- CS20350: Polished grain mount of sample CS20350
- CS20352: Polished grain mount of sample CS20352
- CS20354: Polished grain mount of sample CS20354

## Procedure

The polished grain mounts for EPMA were prepared from vermiculite grains handpicked from the composite samples. The samples were analyzed with a fully automated JEOL JXA-8900 electron microprobe with five wavelength x-ray spectrometers. Operating conditions for the analyses were 15 kV, 20 nA (cup), and a 2 or 5 μm beam diameter depending on the size of the vermiculite grain. Well-characterized silicate and oxide mineral standards were used for calibration. Other well-characterized laboratory standards were used as an internal check on the calibration. The data were normalized to 22 oxygen equivalents using the ZAF correction procedure included with the JEOL software. The analytical errors for EPMA are approximately ±2 percent (1σ) relative concentration for major and minor elements based on replicate analysis of laboratory standards. The quality of each analysis was evaluated using cation and analysis totals as is standard for EPMA of mineral phases (Meeker and others, 2003). Up to 15 grains from each sample were examined. Each data point in Figures 1- 8 represents a single analysis.

## Results

The collected vermiculite data from all samples are attached in a Microsoft® Excel worksheet. The data points were compared to an existing chemical database of "vermiculite" samples compiled by the USGS Denver Microbeam Laboratory (Lowers and Meeker, 2004). The database consists of analyses of "grab samples" and processed ore from various commercial districts and deposits throughout the United States (Libby, MT, Enoree District, SC, and Louisa, VA) and Palabora, South Africa. These samples may not represent the entire range of compositions from any given district or deposit.

Figures 1-7 show the chemical distribution of Al:Mg# (Mg# = Mg/(Mg+Fe)) versus the ratio Al:Ti of vermiculite within each of the database samples. The Troy, Montana data points fall in the field consistent Libby, Montana (Table 1, Figure 1-8). Additional points are present that do not coincide with any of the database fields but are within error of being in the Libby, Montana field.

Table 1. Summary of probable vermiculite sources for submitted samples.

| Sample | Probable Source(s) |
|---|---|
| CS20342 | Libby, Montana |
| CS20344 | Libby, Montana |
| CS20346 | Libby, Montana |
| CS20348 | Libby, Montana |
| CS20350 | Libby, Montana |
| CS20352 | Libby, Montana |
| CS20354 | Libby, Montana |

## Conclusions

The vermiculite analyzed from Troy, Montana is compatible with only one of the sources for which we have previous data. This source is the vermiculite mine at Zonolite Mountain near Libby, Montana. This conclusion is derived from the EPMA data of vermiculite displayed in Figures 1-8. Of these data, many points plot exclusively in the Libby, MT data field. In addition, the data trend from the Troy samples corresponds to the trend observed with vermiculite from Libby, MT (Figs. 1-8).

## References

Meeker, G.P., Bern, A.M., Brownfield, I.K., Lowers, H.A., Sutley, S.J., Hoefen, T.M., and Vance, J.S., 2003. The Composition and Morphology of Amphiboles from the Rainy Creek Complex, Near Libby, Montana: American Mineralogist, v. 88, p. 1955-1969.

Lowers, H.A. and Meeker, G.P., 2004. Electron probe microanalysis as a tool for identifying vermiculite sources: Proceedings of Microscopy and Microanalysis, v. 10, suppl. 2, p. 904-905.

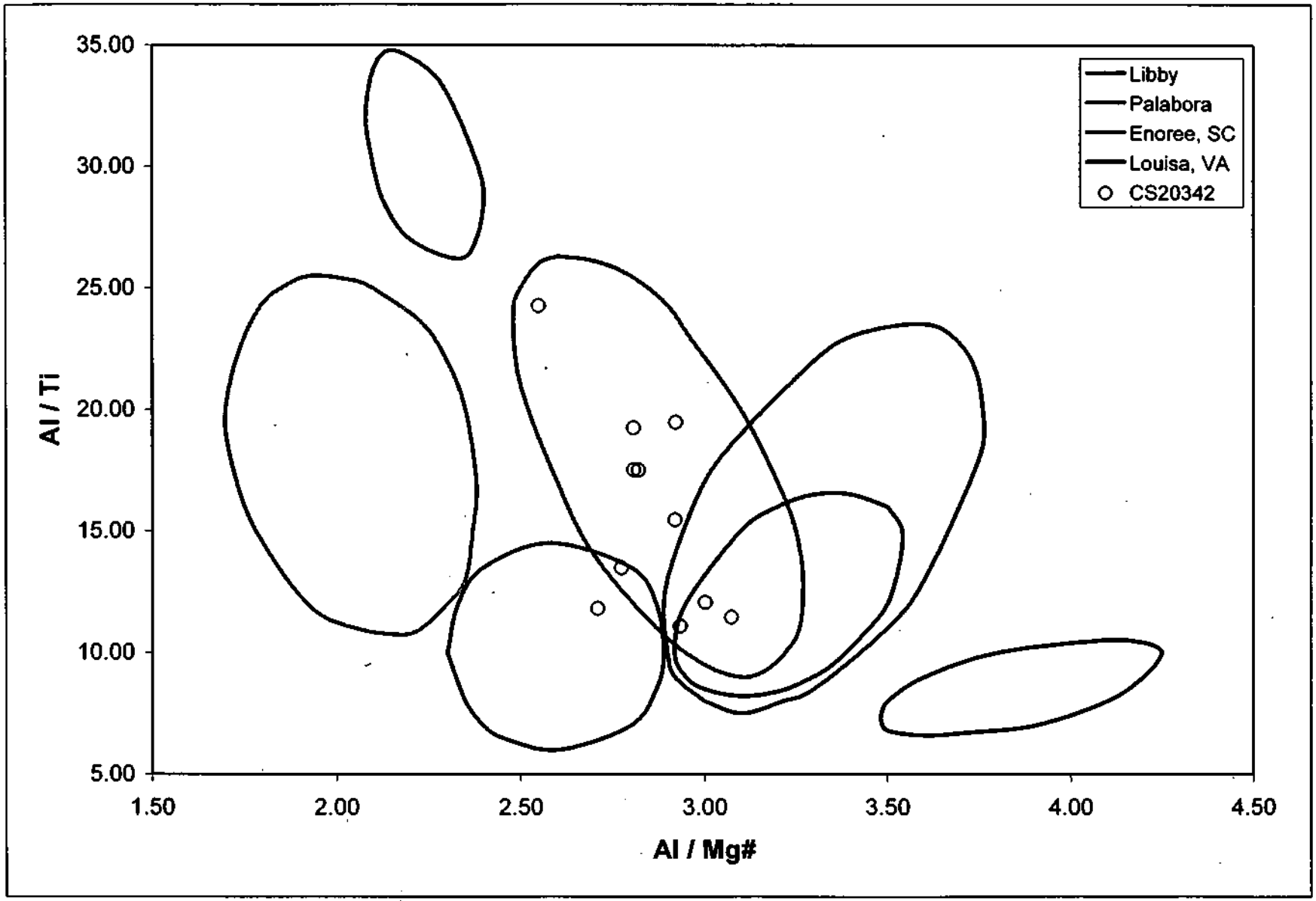


**Figure 1. Chemical representation of CS20342 plotted relative to Denver Microbeam Laboratory vermiculite database.**

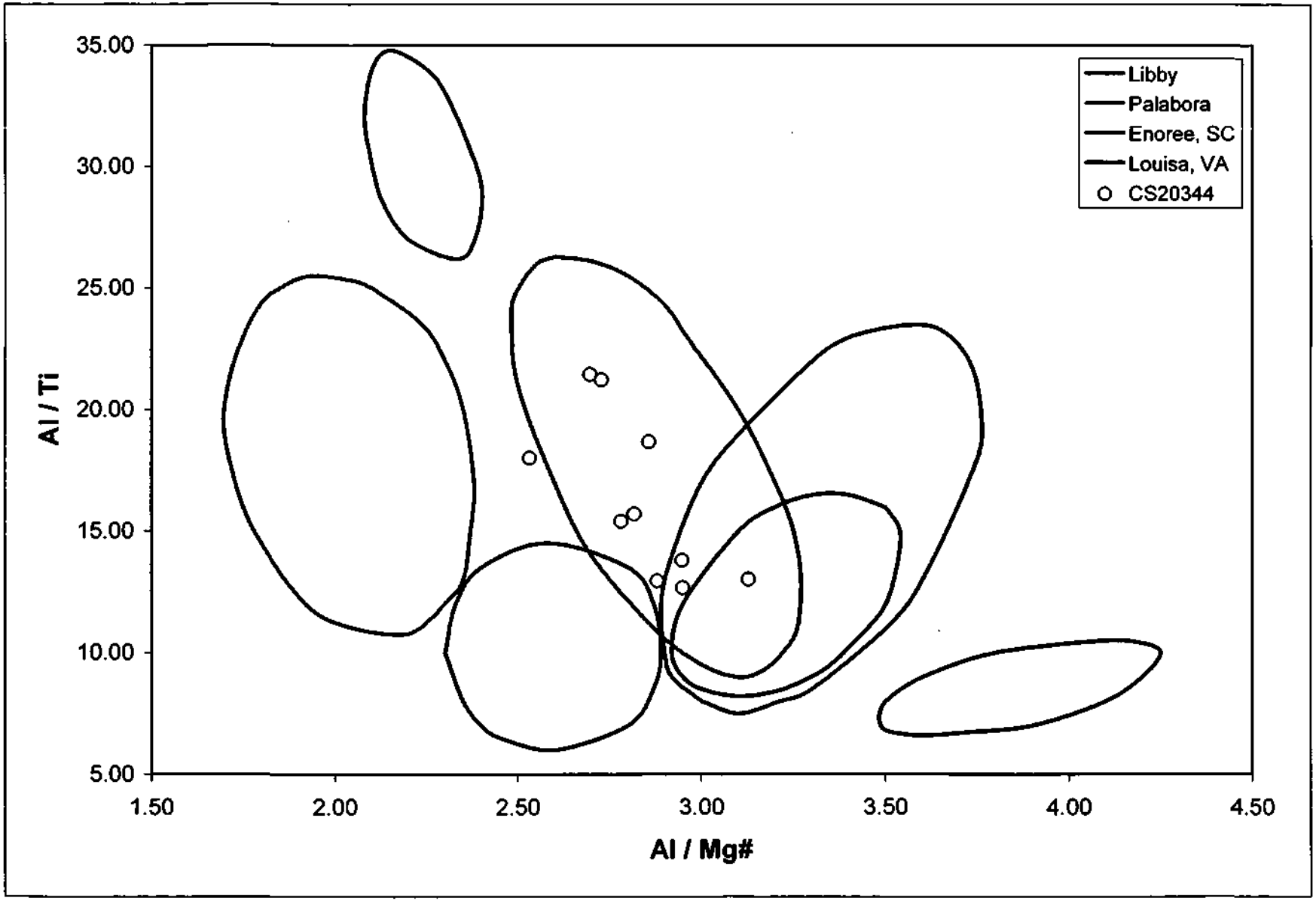


**Figure 2. Chemical representation of CS20344 plotted relative to Denver Microbeam Laboratory vermiculite database.**

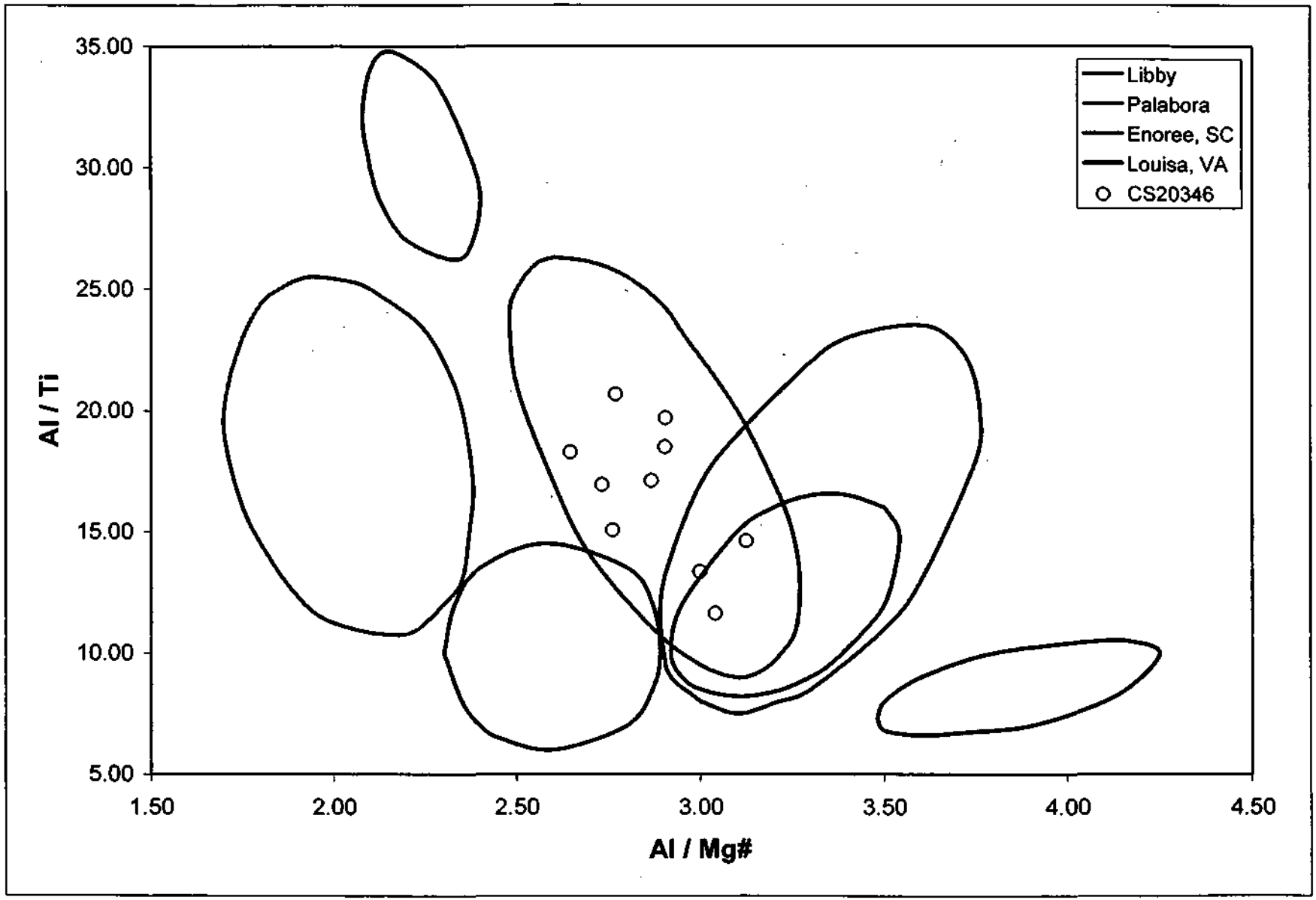


**Figure 3. Chemical representation of CS20346 plotted relative to Denver Microbeam Laboratory vermiculite database.**

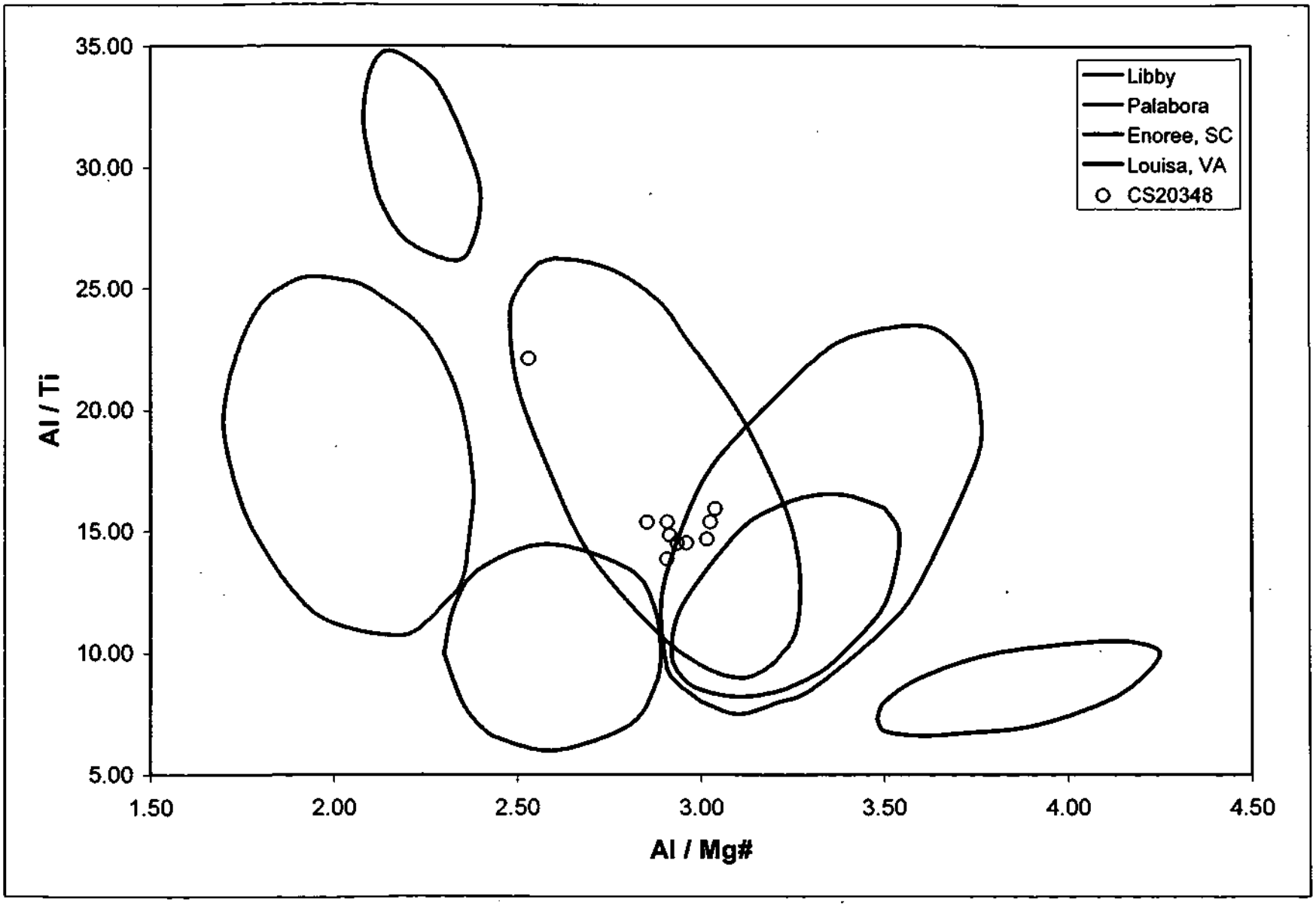


**Figure 4. Chemical representation of CS20348 plotted relative to Denver Microbeam Laboratory vermiculite database.**

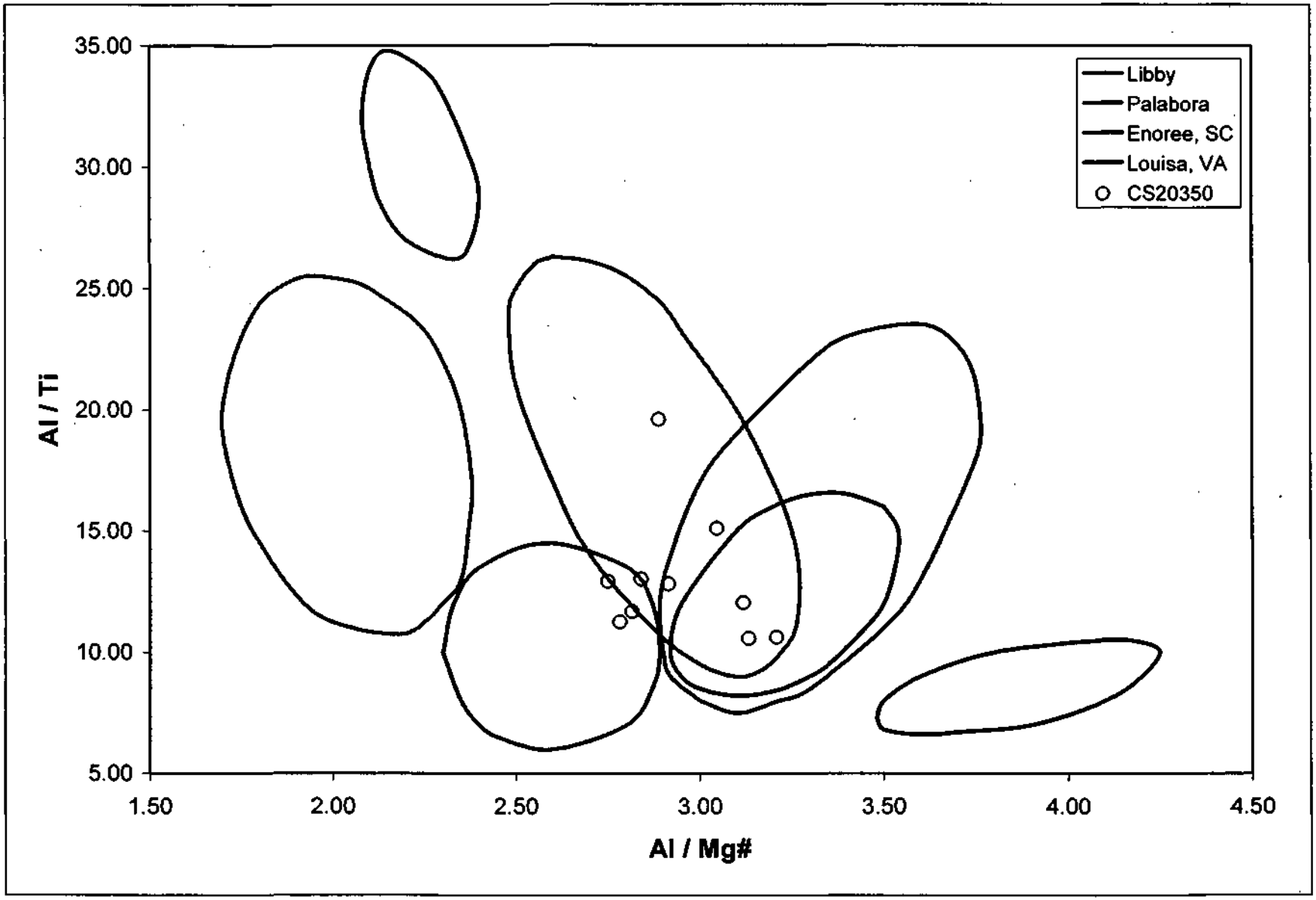


**Figure 5. Chemical representation of CS20350 plotted relative to Denver Microbeam Laboratory vermiculite database.**

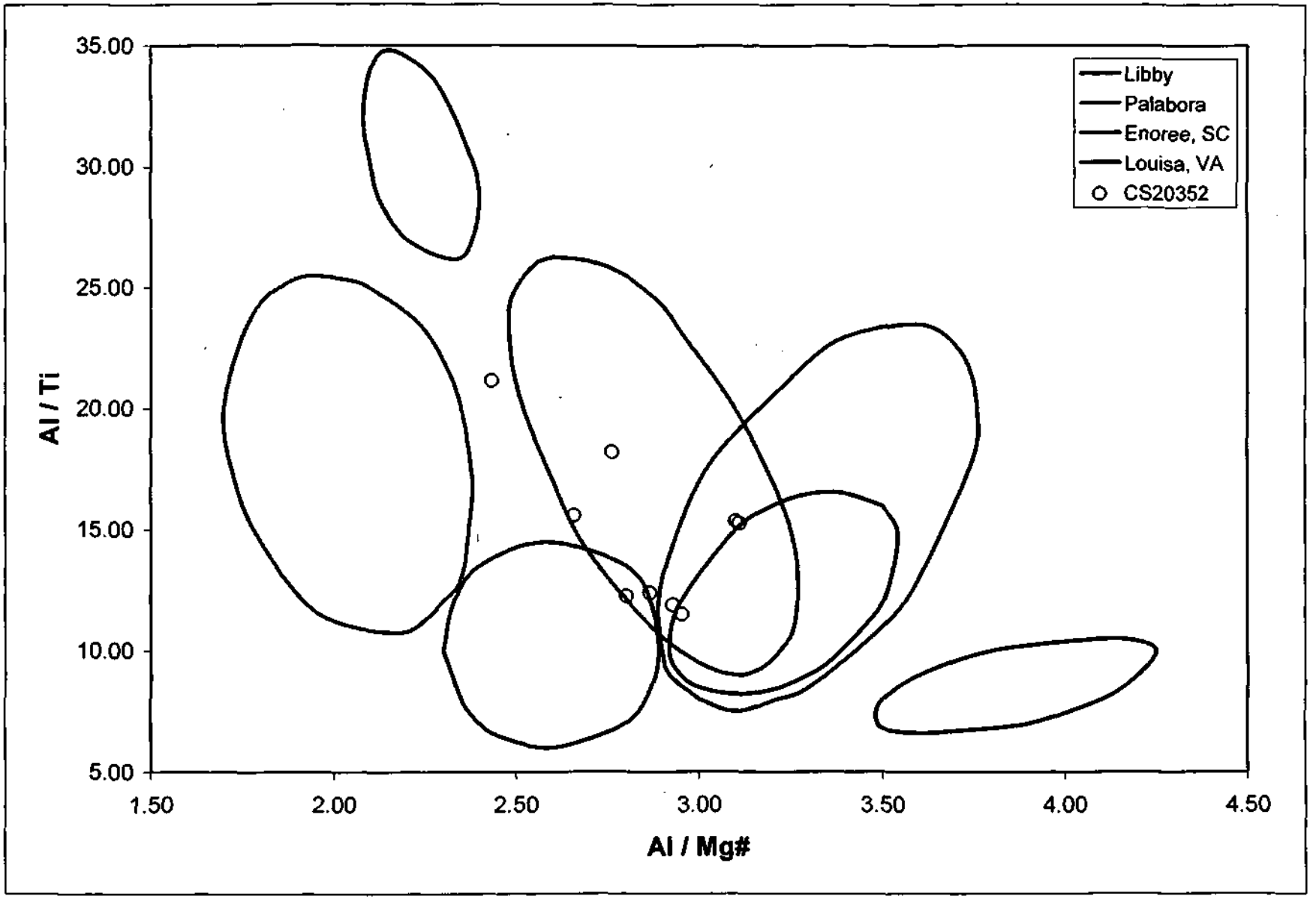


**Figure 6. Chemical representation of CS20352 plotted relative to Denver Microbeam Laboratory vermiculite database.**

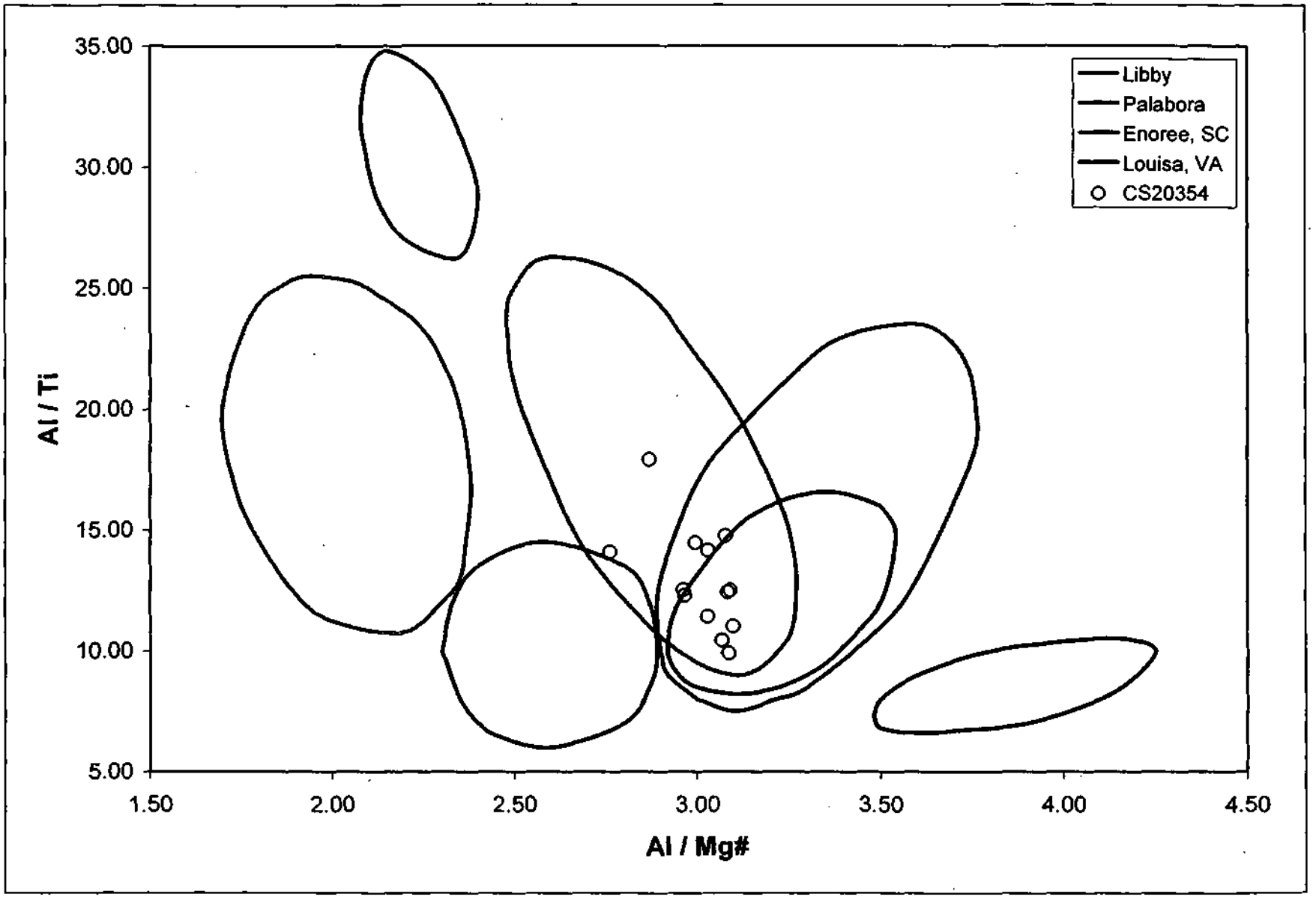


**Figure 7. Chemical representation of CS20354 plotted relative to Denver Microbeam Laboratory vermiculite database.**

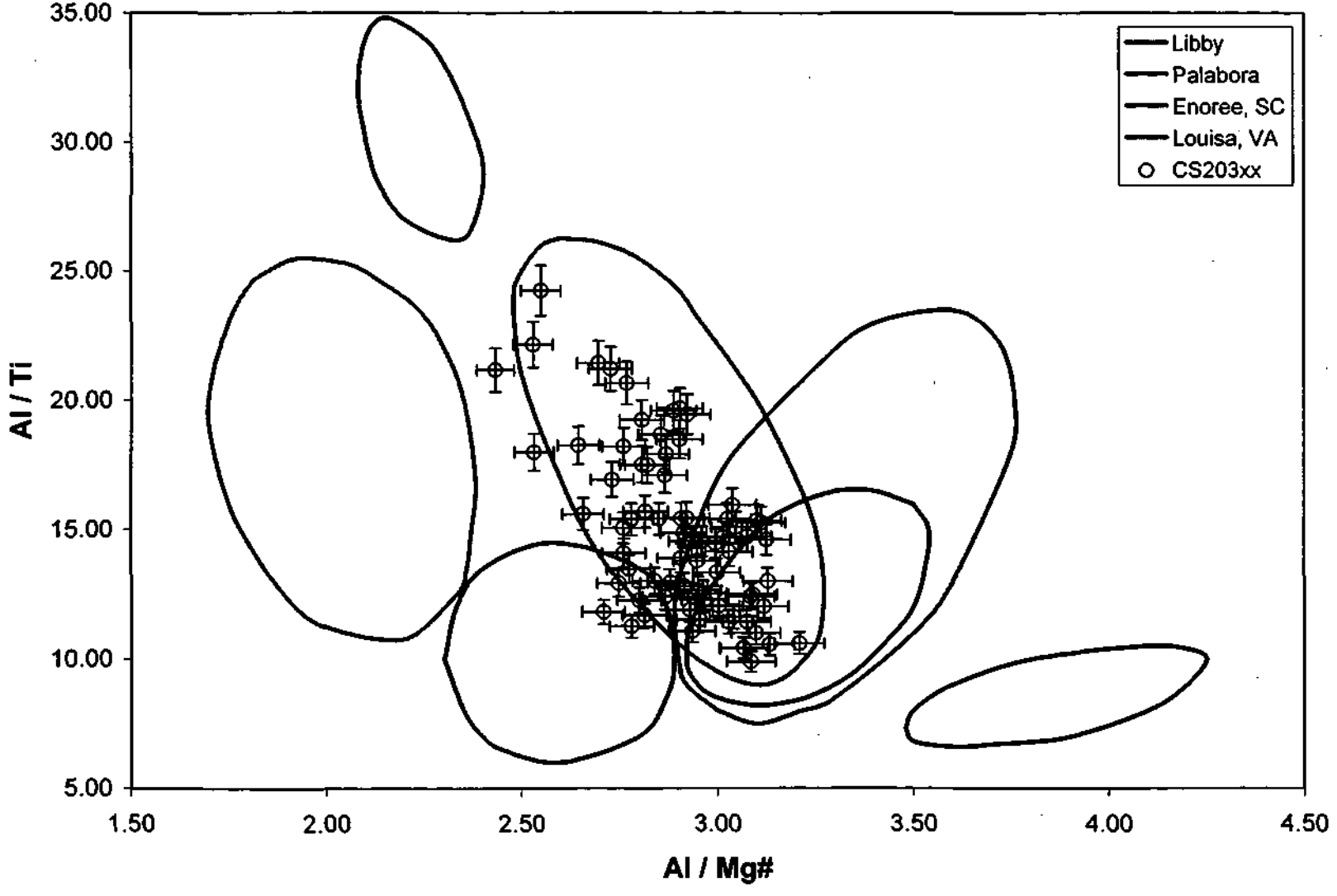


Figure 8. Chemical representation of data from all seven samples plotted relative to Denver Microbeam Laboratory vermiculite database. Error bars are one sigma based on counting statistics.